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# A NEW EXOTIC THREAT TO NORTH AMERICAN HARDWOOD FORESTS: AN ASIAN LONGHORNED BEETLE, *ANOPLOPHORA GLABRIPENNIS* (MOTSCHULSKY) (COLEOPTERA: CERAMBYCIDAE). I. LARVAL DESCRIPTION AND DIAGNOSIS

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*Abstract.*—*Anoplophora glabripennis* (Motschulsky), an Asian longhorned beetle native to eastern China, Korea, and Japan, was discovered in the New York City area attacking various hardwood trees in August 1996. This represents the first known infestation of any member of the lamiine genus *Anoplophora* in North America. To better enable identification of the immature stages of this important exotic forest pest, the mature larva is thoroughly described and illustrated with the use of photomicrographs. In addition, the larva of *A. glabripennis* is compared with North American larvae of the hardwood-feeding genera *Xylotrechus*, *Neoclytus*, *Saperda*, and *Glycobius* and of the conifer-feeding, morphologically similar genus *Monochamus*.

*Key Words:* Cerambycidae, longhorned beetle, *Anoplophora*, exotic pest

Borers of the beetle family Cerambycidae comprise one of the economically most important groups of insect pests of hardwood trees in the world (Craighead 1923, Drooz 1985, Solomon 1995). Cerambycid larvae are borers in dead wood, and their principal ecological role involves the reduction of dead and dying trees, broken branches, and slash (Haack and Slansky 1987, Bíly and Mehl 1989). However, some species attack living or slightly weakened and stressed trees, and many are capable of causing serious injury or even death of their host (Linsley 1959).

Members of the lamiine genus *Anoplophora* Hope infest living, and apparently healthy, hardwood trees. The 30+ species (and subspecies) of the genus are endemic to the Oriental and eastern Palearctic regions (Breuning 1943–45). *Anoplophora chinensis* (Förster) is considered one of the most destructive longhorned beetles in the world and is a serious pest in China (Duffy 1968). Associated with a wide range of ornamental host plants, this species infests fruit trees throughout lowland orchards in China and can become extremely abundant (Wang et al. 1996). Gressitt (1942) noted that *A. chinensis* infested an estimated 90% of all *Citrus* trees on the Lingnan University (now Zhong Shan) campus in China, and that this pest kills many young *Citrus* trees annually despite preventive measures. Another important pest, *A. malasiaca* (Thomson), the white-spotted longhorned beetle, is widely distributed throughout most of Japan, China, and Malaysia. Larvae of this species develop in the phloem and xylem of living trunks of citrus, apple (*Malus*), pear (*Pyrus*), and numerous other trees, and cause the deterioration or death of trees, resulting in serious economic damage (Adachi 1994). *Anoplophora glabripennis,* native to the eastern provinces of China, Korea, and Japan, is one of the most important pests in poplar (*Populus*) plantations of eastern China (Yan 1985). Primarily a trunk and large branch borer, this species also severely damages a variety of other Asian hardwood trees, including maple (*Acer*), willow (*Salix*), elm (*Ulmus*), and mulberry (*Morus*). Early instar larvae of *A. glabripennis* initially feed beneath the bark, destroying the cambial tissue, and late instar larvae seriously weaken trees by feeding in both sapwood and heartwood, where numerous larval tunnels often cause tree breakage and death.

Established populations of *A. glabripennis* were detected in the New York City area (mostly in the Greenpoint and Williamsburg sections of northern Brooklyn, and in a small area of southern Queens) in late August 1996, and again in a few small communities around Amityville, Long Island, in September 1996, infesting various hardwood trees, especially maples, along streets, and in parks and yards. Evidence strongly suggests that this immigrant cerambycid probably gained entry into North America through wood crating and palleting, or other large-dimensional wood blocking used in bracing and stacking cargo during transport from the Far East, and particularly China. Since the winter of 1996–1997, federal and state quarantine officials have attempted to eradicate this new exotic forest pest from the two infested New York sites. Regulators must remove and destroy all trees showing symptoms of attack, because other control methods are ineffective for this pest (Haack et al. 1997).

Because adult *A. glabripennis* will be found only in summer to autumn, conclusive recognition of the larval stage is crucial to eradication and control efforts in New York, especially to facilitate tree removal decisions and early detection of new infestations. The object of this paper is to provide a detailed description and a diagnosis of the larva of *A. glabripennis,* with photomicrographs of diagnostic features, to enable regulatory officials and taxonomists to identify this important pest species of hardwood trees. A forthcoming paper will provide a description and illustrations of the adult beetle, and a summary of its biology and seasonal history, its host trees, damage symptoms, and native geographic range.

## Materials and Methods

The description provided below is based, in part, on the published work of Xiao (1980) and on our own examination of numerous mature and early instar larvae of *A. glabripennis* extracted from infested Norway maple trees (*Acer platanoides* L.) in Brooklyn and Amityville, New York. The terminology used in the description is partially modified from Craighead (1923), Duffy (1953, 1968), Xiao (1980), and Torre-Bueno (1989).

Except for Fig. 1, the photographs in this paper were taken by Steven Passoa, in color, with 35 mm film or a SONY DXC-107A video camera and UP-1200 video printer, using either a Zeiss Photomic 2, Zeiss Tessovar, Nikon Optiphot 2, Nikon Multiphot, or Wild M5A Apochromat dissecting microscope. However, for the purposes of this paper, all figures, except Fig. 1a and 1b, were reproduced in black-and-white.

## Larval Description

Mature larva.—Length to 50 mm; head capsule width to 5 mm. *Body* (Fig. 1a, 1b): Elongate, cylindrical, fleshy, pale yellow. *Head* (Fig. 2a, 3): Elongate-oblong, sides

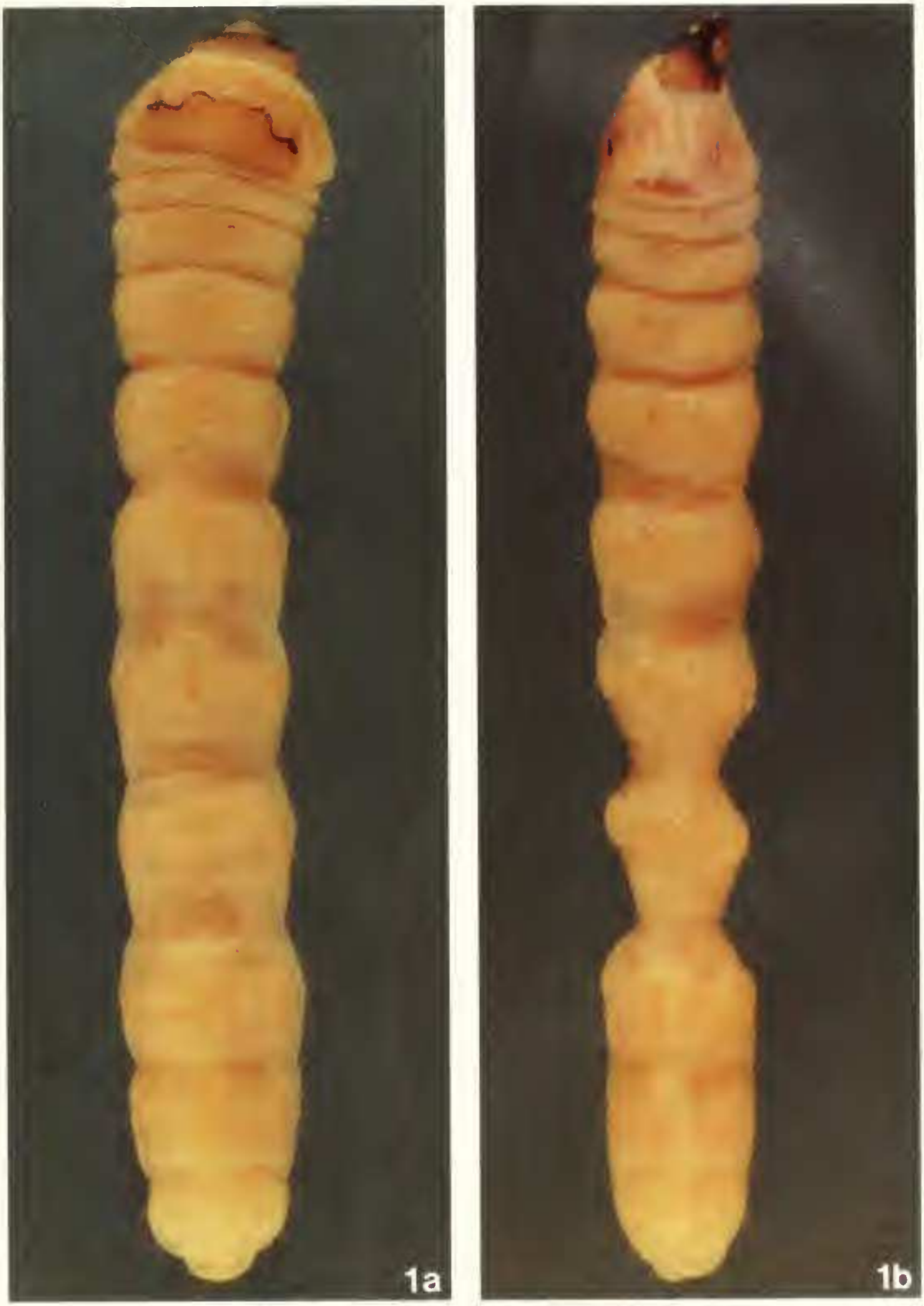
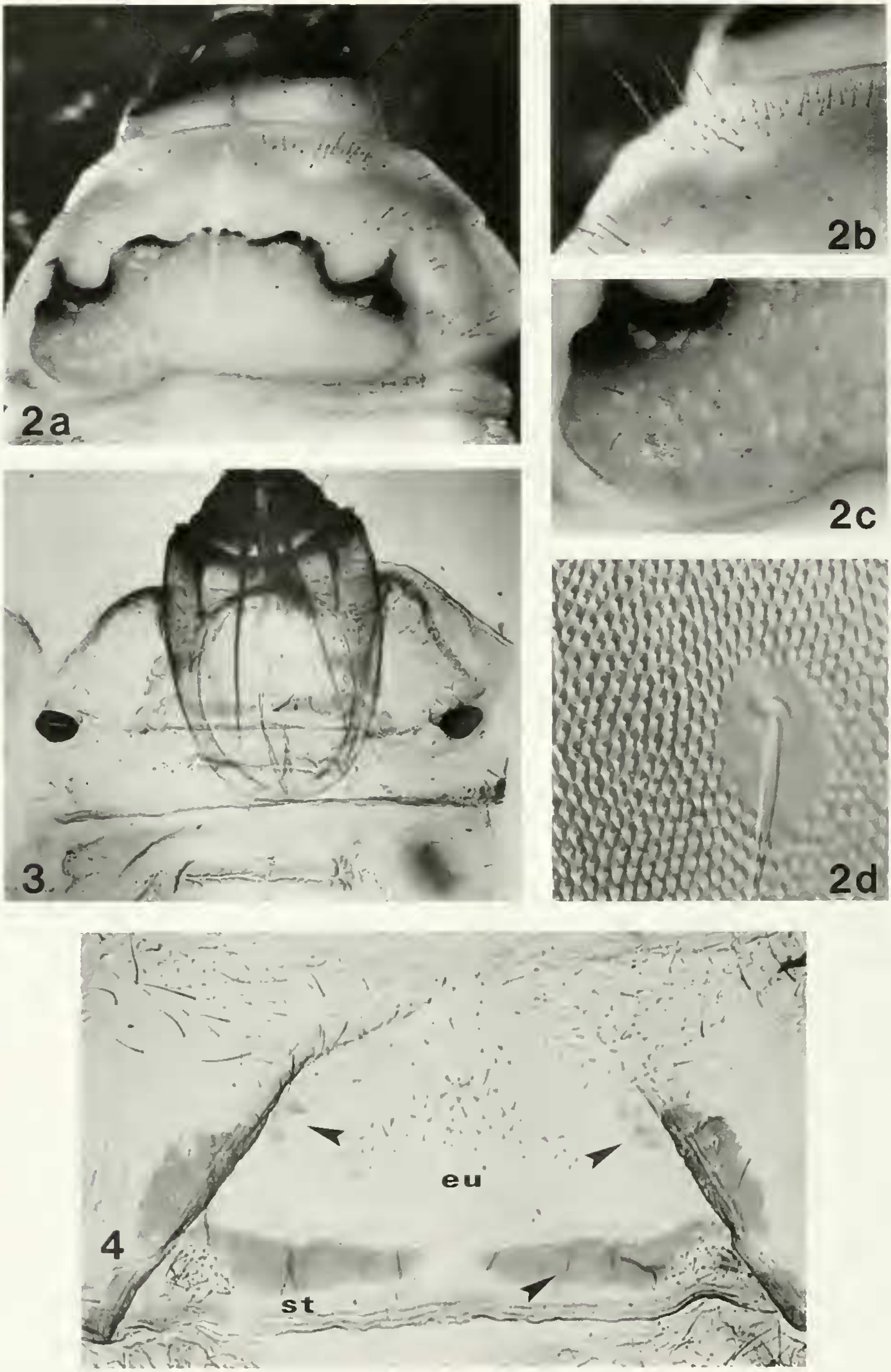
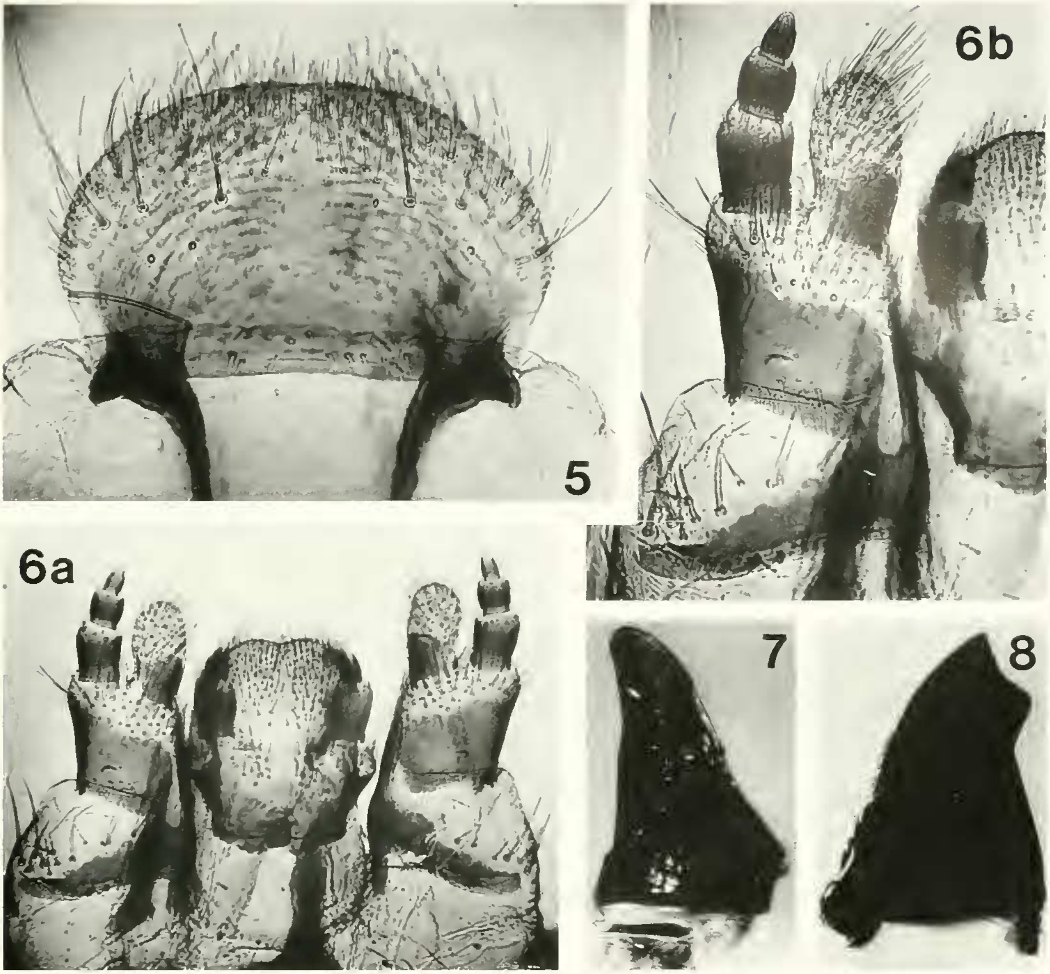



Fig. 1. Larval habitus of *Anoplophora glabripennis*. 1a, Dorsal habitus. 1b, Lateral habitus.

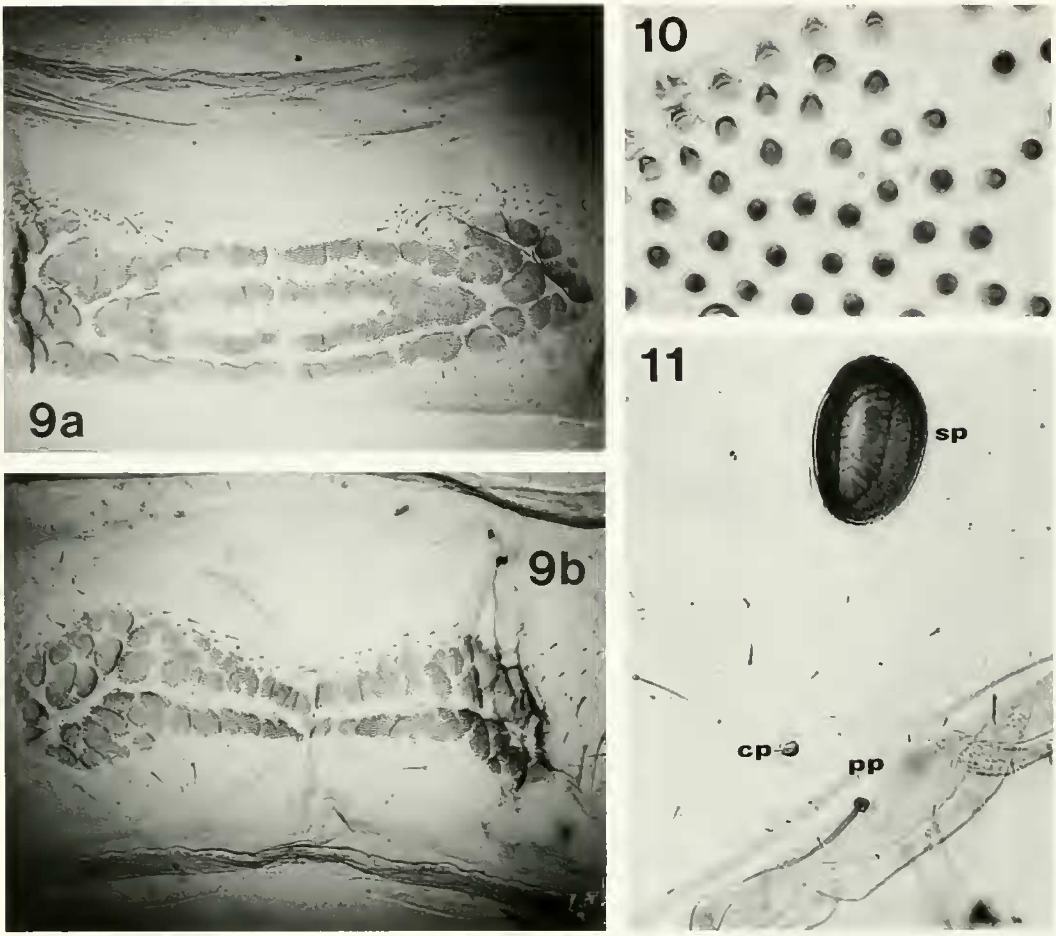



Figs. 2–4. Anatomical features of *Anoplophora glabripennis*. 2a, Dorsal view of head and thorax. 2b, Close-up of pronotal subapical setae. 2c, Close-up of pronotal spiculose region showing increasing density of spicules towards anterior margin of raised posterior sclerotization. 2d, Close-up of pronotal micro-spiculose region showing a non-spiculose pit or depression. 3, Venter of head and thorax. 4, Close-up of prosternum showing characteristic small, micro-spiculose patchs (arrows) of eusternum (eu) and transverse patches of sternellum (st).




Figs. 5–8. Anatomical features of *Anoplophora glabripennis*. 5, Labrum. 6a, Maxillae and labium. 6b, Close-up of maxilla. 7, Left mandible, lateral view of biting surface. 8, Left mandible, outer (anterior) face.

parallel, two-thirds retracted into thorax, reddish brown; mouthparts prognathous. Antenna 3-segmented, short, with segments 2 and 3 sclerotized, length of segment 2 equal to its width, segment 2 bearing a hyaline process, or supplementary joint, ventrad of and subequal in length to segment 3. Frons with coarse, mostly round, setiferous punctures. Single ocellus proximal to and posteroventrad of antenna. Labrum (Fig. 5) yellowish, semicircular, dorsum with dense, long, erect setae. Clypeus yellowish, trapezoidal in shape. Maxilla as in Fig. 6a, 6b; maxillary palpus (Fig. 6b) brownish, 3-segmented. Labium as in Fig. 6a; labial palpus brownish, 2-segmented. Mandible (Figs. 7, 8) stout, heavily sclerotized, with oblique cutting edge behind pointed apex, and with 2 setae on basal one-third of outer face. *Thorax* (Figs. 1–4): Without legs. Pronotum (Fig. 2) with transverse band of rather dense, long, stiff setae along the anteapical margin (Fig. 2b). Anterior area (Fig. 2a, 2b), or apical one-third, of pronotum pale yellow, lightly sclerotized, densely covered with shallow pits or wrinkles, with sparse setae similar to those comprising ante-apical pronotal band, and with evident, smooth midline. Posterior area (Fig. 2a, 2c, 2d), or basal two-thirds,




Figs. 9–11. Anatomical features of *Anoplophora glabripennis*. 9a, Dorsal abdominal ampullae of segment IV. 9b, Ventral abdominal ampullae of segment IV. 10, Close-up of micro-spicules on abdominal ampullae. 11, Abdominal spiracle (sp), pleural plate (pp), and chitinous pit (cp).

of pronotum much darker yellow, distinctly raised, more heavily sclerotized; anterior margin of posterior area distinctly shaped, with margin (Fig. 2a, 2c) very narrowly dark brown to ferrugineous, slightly bisinuate at middle and strongly undulate laterad; remainder of raised posterior area micro-spiculose (Fig. 2c) and also bearing moderately dense, elongate, shallow, pale pits (Fig. 2d), and sparsely clothed with finer, shorter setae. Conspicuous, pigmented micro-spiculose patches on sternellum and presternum (Figs. 3, 4), and very small separate patches on eusternum (Fig. 4). Mesothorax short, with transverse, irregular band or row of coarse, long setae (no dorsal ampullae), and with ventral ampullae. Meso- and metathoracic ventral ampullae bordered by anterior row of short setae and lateral swollen areas set with setae of varied lengths. *Abdomen* (Figs. 1, 9–11): With 10 visible segments, segment 10 with nipple-like apophysis; segments 7–9 much wider and more flattened than segments 1–6. Segments 1–7 with distinct dorsal ampullae arranged in 4 transverse rows, converging at sides and appearing as 2 narrow, micro-spiculose rings (Fig. 9a). Ampullae also scattered at sides where transverse rows converge. Ampullae covered with reddish-brown spicules (Fig. 10). Ventral ampullae of segments 1–7 (Fig. 9b) form two rows converging at middle and diverging at sides; anterior row consists of two fused lines of ampullae and posterior row consists of single line of ampullae. Abdominal spiracles smaller than mesothoracic spiracle, with spiracular openings typically less than 1.8 times as long (dorsal/ventral axis) as greatest width (anterior/posterior axis), appearing broadly oval (Fig. 11). Pleural tubercle or plate (Fig. 11) somewhat broadly oval, lightly sclerotized, and with at least 2 well-defined, long, erect setae, but sometimes with additional shorter hairs; pleural plate with chitinous pit or pore at anterior and posterior extremities. Anus trilobate.

Specimens examined.—NEW YORK: Kings Co., Brooklyn (Greenpoint), 30-III-1997 (8); (Williamsburg), 14-X-1997 (5). Suffolk Co., Amityville, 30-VII-1997 (12).

Specimens preserved in 70% ethanol and deposited in the Cornell University Insect Collection, Ithaca, New York, and the National Museum of Natural History, Smithsonian Institution, Washington, DC.

## Diagnosis

The only North American cerambycid larvae likely to be mistaken for *Anoplophora glabripennis* are those belonging to the conifer-feeding lamiine genus *Monochamus* Megerle. Other hardwood-feeding cerambycid larvae in the United States, particularly species of *Xylotrechus* Chrevolat, *Saperda* Fabricius, *Neoclytus* Thomson, and the sugar maple borer, *Glycobius speciosus* (Say), are easily distinguished from those of *Anoplophora*. *Xylotrechus*, *Neoclytus*, and *Glycobius* belong to the subfamily Cerambycinae and are recognized by the usually visible thoracic legs (rudimentary in *Xylotrechus*), narrow and projecting clypeus and labrum, and prosternum with one or two longitudinal impressions medially. Larvae of the lamiine genus *Saperda* are recognized by the poorly delineated eusternum with a large spiculose patch on each side, very large asperites on posterior two-thirds of the pronotum, anterior margin of the posterior, sclerotized portion of the pronotum not well differentiated from the remainder (well differentiated in *Anoplophora*), and very large depression on the head above the antenna (small depression in *Anoplophora*).

The larvae of *A. glabripennis* can be distinguished from *Monochamus* spp. chiefly by characters of the pronotum, prosternum, and dorsal and ventral ampullae. Illustrations of *Monochamus* spp. can be found in Craighead (1923) and Hellrigl (1970). In *A. glabripennis*, the anterior area of the pronotum is well differentiated from the posterior area in being very lightly sclerotized, the surface integument slightly wrinkled and glabrous, and light yellow in color. In contrast, the posterior pronotal area is more heavily sclerotized, raised, and has a brown pigmented, densely spiculose surface. The anterior border of the posterior region is much more densely spiculose, appearing to have a dark brown or black delineation (as in Fig. 2a, 2c). This region also has small, scattered, non-spiculose punctures. In *Monochamus* spp., there is no obvious distinction between the anterior and posterior areas except for the posterior region being moderately micro-spiculose, but unpigmented. The coloration and sclerotization of both regions are similar. The larvae of *A. glabripennis* also have a distinctive prothoracic venter. There are conspicuous, pigmented micro-spiculose patches on the sternellum and presternum, and very small separate patches on the eusternum (Fig. 4). *Monochamus* larvae differ in having a large, inconspicuous (only visible after integument is dry), non-pigmented micro-spiculose patch at the posterior corners of the eusternum and continuing over the invagination to the posterior margin of the presternum and sternellum. The last major difference between *A. glabripennis* and *Monochamus* spp. involves the dorsal and ventral abdominal ampullae. In both taxa, these ampullae are covered with spicules (Fig. 10). These are conspicuous and colored reddish brown in *A. glabripennis*, but in *Monochamus* they are non-pigmented and visible only after the integument dries. In *A. glabripennis*, the dorsal abdominal ampullae are arranged in 4 transverse rows, converging at the sides and appearing as 2 narrow, micro-spiculose rings (Fig. 9a). These ampullae are also scattered at the sides where the transverse rows converge. In *Monochamus* spp., the dorsal ampullae are more scattered, usually neither in rows nor rings, and have a more warty (tuberculate) appearance. The ventral ampullae in *A. glabripennis* form 2 rows, converging at the middle and diverging at the sides (Fig. 9b). In *Monochamus* spp., the ventral ampullae, like the dorsal, are more scattered, creating a warty appearance. The abdominal spiracles also show some differences between *A. glabripennis* and *Monochamus* spp., although not as discrete. In *A. glabripennis,* the spiracular openings are typically less than 1.8 times as long (dorsal/ventral axis) as the greatest width (anterior/posterior axis), appearing broadly oval (Fig. 11). In *Monochamus* spp., the spiracular openings are more narrow, usually at least twice as long as the greatest width. This character does show some variability, however, and will not consistently separate the two taxa.

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